



# Mercury in the Environment and Human Health Effects

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# **SOURCES OF MERCURY IN THE ENVIRONMENT**

**Three different forms: Elemental (metallic), inorganic (mercuric salts), and organic.**

**Occurs naturally in cinnabar ore.**

**Released through weathering and volcanic activity.**

## **Human Activities**

**Careless use, disposal of elemental Hg**

**Solid waste incineration/disposal.**

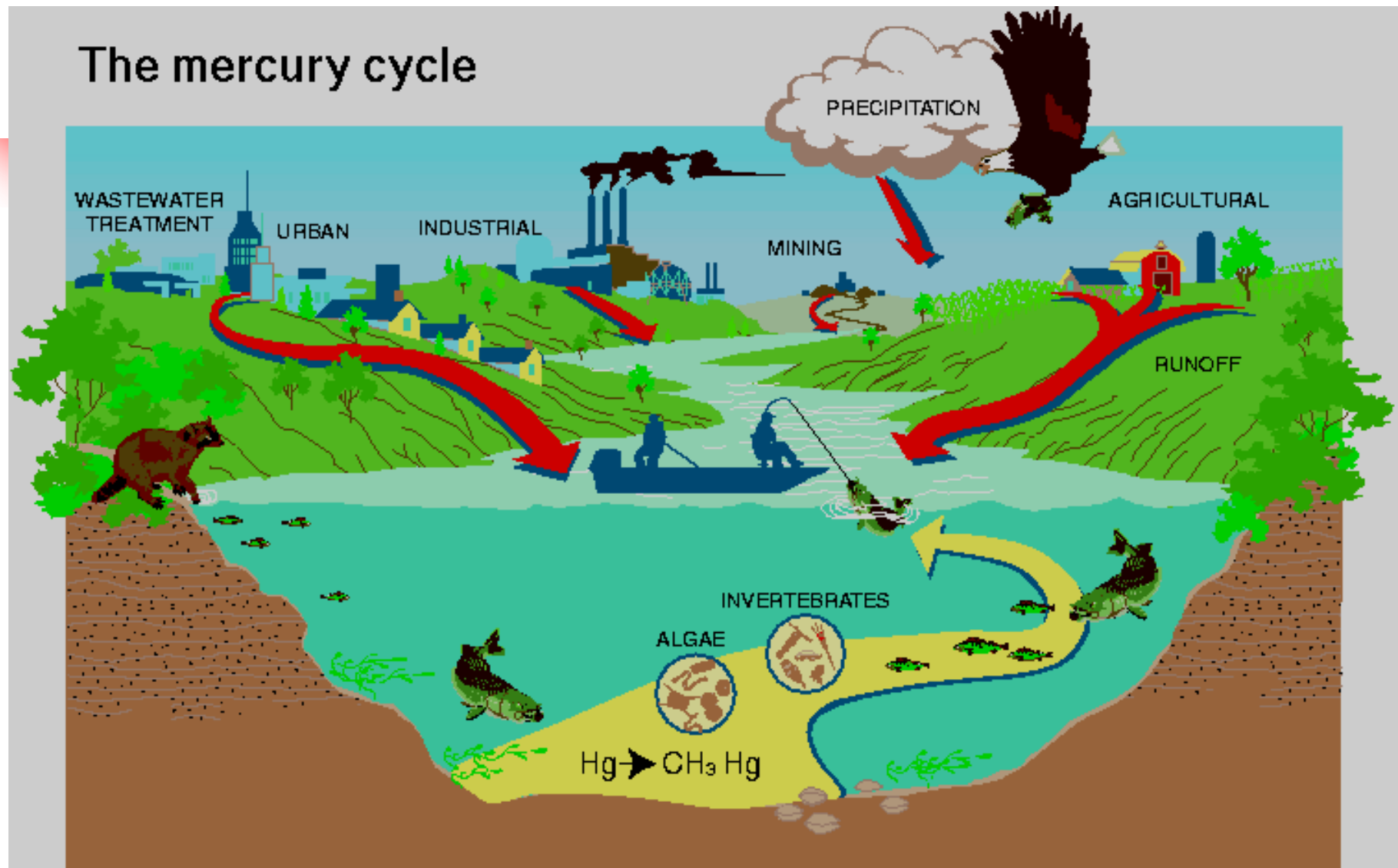
**Fossil fuel combustion.**

**Mining and smelting.**

**Industrial processes such as chlor-alkali production.**

**Use of fertilizers and fungicides.**

# The mercury cycle



(Illustration by Connie J. Dean, U.S. Geological Survey)



# Mercury Chemistry

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- Elemental Hg (as found in thermometers) is poorly absorbed from the gut (0.01%).
- Elemental Hg can vaporize and be inhaled.
- Elemental & inorganic mercury can be transformed into methylmercury ( $\text{CH}_3\text{Hg}$ ) by bacteria.
- Methylmercury is almost completely absorbed by the gut.



# Elemental Mercury Toxicity

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- Metallic mercury is rapidly absorbed by lung; 80% retained; very little absorbed by gut
- Passes blood brain barrier (conjugated to L-cysteine);
- Toxic to the lung, brain, kidney at high levels
- inflammation of gums, oral mucosa; tremor, erethrism (memory loss, emotional lability, depression, insomnia, shyness, changes in mood)



# Methylmercury

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- Quickly enters the aquatic food chain.
- In fish  $\sim 99\%$  of mercury is  $\text{CH}_3\text{Hg}$ .
- Methylmercury is found primarily in fish muscle bound to protein.
- Skinning and trimming the fish does not reduce mercury concentration, nor is it removed by the cooking process.
- Methylmercury levels in predator fish are 7 million times higher than surrounding water.



# Mercury Concentrations for Selected Fish Species – NE/Canada

SPECIES	AVERAGE CONC. (ppm)	RANGE (ppm)
Largemouth bass	0.51	0 - 8.94
Smallmouth bass	0.53	0.08 - 5.0
Yellow perch	0.40	0 - 3.15
Pickeral	0.64	0 - 2.81
Lake trout	0.32	0 - 2.70
Walleye	0.77	0.1 - 2.04
Brown bullhead	0.20	0 - 1.10
Brook trout	0.26	0 - 0.98
<i>Source: NESCAUM 1998</i>		

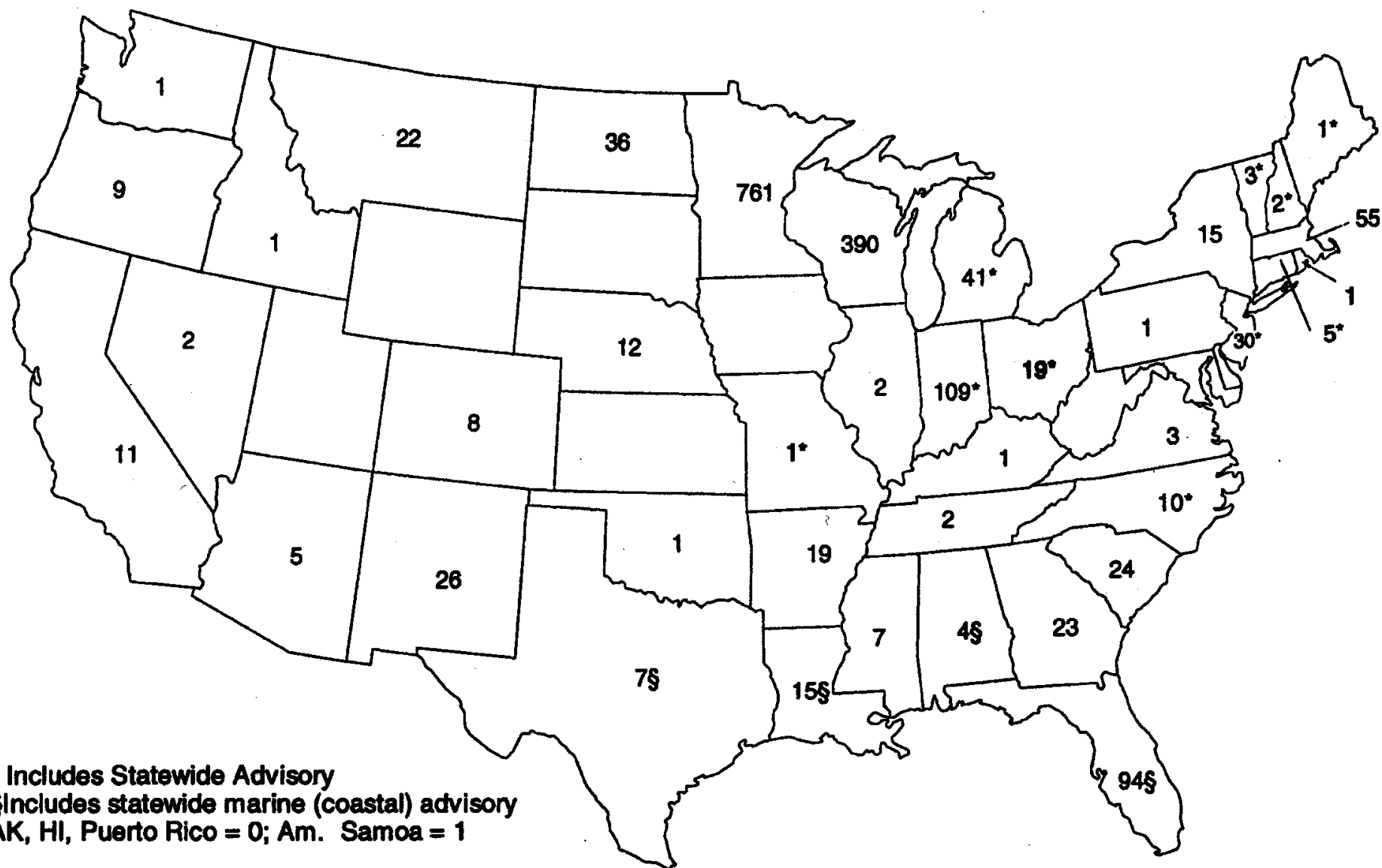


# Fish Advisories for Mercury

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- As of 1999, 1931 fish consumption advisories have been issued by 40 states.
- Ten states have issued statewide advisories for mercury for freshwater bodies: CT, IN, ME, MA, MI, NH, NJ, NC, OH, VT.
- Five coastal states have statewide mercury advisories for marine waters.

**Figure 5-7. Listing of Fish and Wildlife Consumption Advisories Issued for Mercury**



\* Includes Statewide Advisory  
 §Includes statewide marine (coastal) advisory  
 AK, HI, Puerto Rico = 0; Am. Samoa = 1

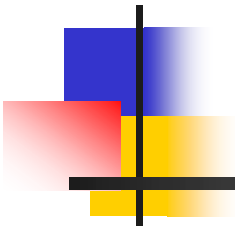
Source: EPA 1998



# What Level is Safe?

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“The Dose Makes the  
Poison”





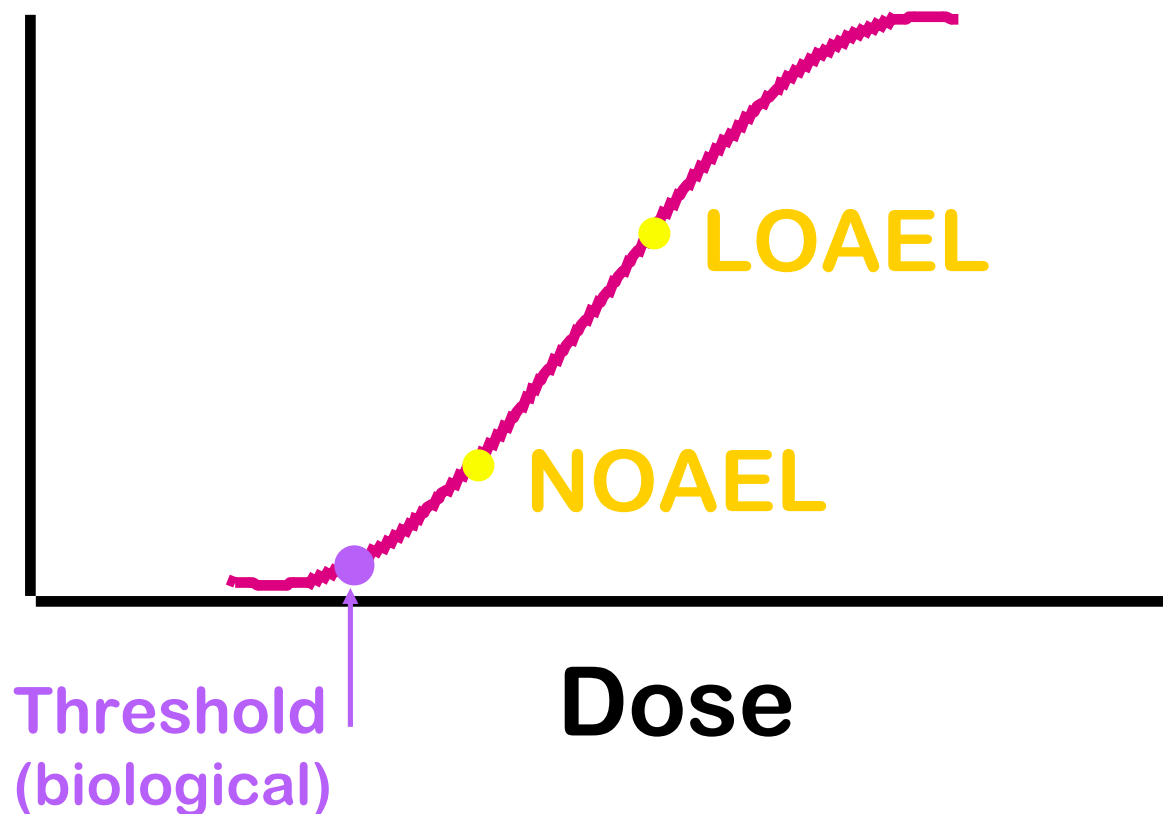
# Two Aspects of Dose:

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- Inherent Toxicity of a Substance.
  - i.e. potency, dose:response.
- Degree of Exposure:
  - How much? How long? How frequent? By what route?

# Dose Response Curve

Incidence  
of Effect





# Factors that Affect Toxicity

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- Inherent Potency
- Route, Duration, Frequency
- Genetics, Age, Gender
- Diet and General Health
- Multiple Exposures



# Methylmercury Toxicity

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- $\text{CH}_3\text{Hg}$  toxicity to humans recognized since the late 1950's.
- First known epidemic of  $\text{CH}_3\text{Hg}$  poisoning occurred in Minimata Bay, Japan.
  - Industrial release into bay.
  - Effects were seen in newborn, infants, children, and adults.
  - Effects mainly neurotoxic and developmental.



## Methylmercury Toxicity (cont.)

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- $\text{CH}_3\text{Hg}$  contaminated wheat intended for planting used to make bread in Iraq.
- > 400 people died.
- Children exposed in utero experienced delayed development in walking/talking.
- Mothers showed few obvious symptoms of Hg poisoning yet gave birth to children with severe mental and physical retardation.



## Methylmercury Toxicity (cont.)

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- No longer any doubt about the ability of  $\text{CH}_3\text{Hg}$  to produce deleterious effects in humans, determining the exposure level that will not cause adverse health effects more problematic.
- Available data indicate that population of greatest concern consists of women of child bearing age and infants.
- Subtle effects of low-dose exposure had to be extrapolated from data from acute, high-dose poisonings.

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- Three recent studies conducted to address question of low-level CH<sub>3</sub>Hg exposure through consumption of fish (**exposures within range in US**).

- **Seychelles Islands** – investigated effects of prenatal exposure to CH<sub>3</sub>Hg through maternal fish consumption. 740 mother-infant pairs. Results: no definite adverse effects observed in infants/children.
- **New Zealand** – Similar to Seychelles Island study, more ethnically diverse. Results: no Hg-related abnormalities observed based on clinical exam, however, neuropsychological dysfunctions in language, attention, and memory were observed.
- **Faroe Islands** – Looked at > 1000 children of mothers who consumed fish. Results: no Hg-related abnormalities observed based on clinical exam. however. neuropsychological dysfunctions



# Current Standards

Agency	Intake Level	Description
FDA	0.47 ug/kg/day*	Action Level
EPA	0.10 ug/kg/day	RfD
ATSDR	0.30 ug/kg/day	MRL
NRC	0.10 ug/kg/day	confirm RfD
Washington State DOH	0.035 - 0.08 ug/kg/day	TDI

*\*FDA - Established 1 ppm for regulation of commercially harvested fish*

*FDA assumes a consumption rate of 7 oz. per week*

*Value is back calculated to derive intake level.*



## NAS/NRC Report

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- “The population at highest risk is the children of women who consumed large amounts of fish and seafood during pregnancy. ...the risk to that population is likely to be sufficient to result in an increase in the number of children who have to struggle to keep up in school and who might require remedial classes or special education.”



## NAS/NRC Report

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- "...the risk of adverse effects from the current CH<sub>3</sub>Hg exposures in the majority of the population is low. However, individuals with high CH<sub>3</sub>Hg exposures from frequent fish consumption might have little or no margin of safety (i.e., exposures of high-end consumers are close to those with observable effects)."



# Calculating a Safe Consumption Rate

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$$\text{Grams fish per day} = \frac{(\text{TDI} \times \text{BW} \times \text{UCF})}{\text{Conc. HG in fish}}$$



# Uncertainties

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- Time period for averaging exposure?
- What level is safe for the general population?
- Other endpoints (cardiovascular & reproductive).
- Total exposure?
- How to weigh risks/benefits.



# Weighing Risks and Benefits

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- Fish are a major source of exposure to certain contaminants.
  - i.e., Hg and PCBs.
- Fish are a healthy source of protein that is low in saturated fats, rich in vitamin D, and omega-3 fatty acids. Fish is good food!
- Reduction in cardiovascular disease, osteoporosis, reduction of certain cancers.